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Arao et al.

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(54) **OPTICAL MODULE**

(71) Applicant: **SUMITOMO ELECTRIC INDUSTRIES, LTD.**, Osaka-shi, Osaka (JP)

(72) Inventors: **Hajime Arao**, Yokohama (JP); **Toshihisa Yokochi**, Yokohama (JP); **Atsushi Suzuki**, Yokohama (JP); **Mitsuaki Tamura**, Yokohama (JP)

(73) Assignee: **SUMITOMO ELECTRIC INDUSTRIES, LTD.**, Osaka-shi, Osaka (JP)

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G02B 6/38 (2006.01)

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USPC 385/14, 15, 31, 39
See application file for complete search history.

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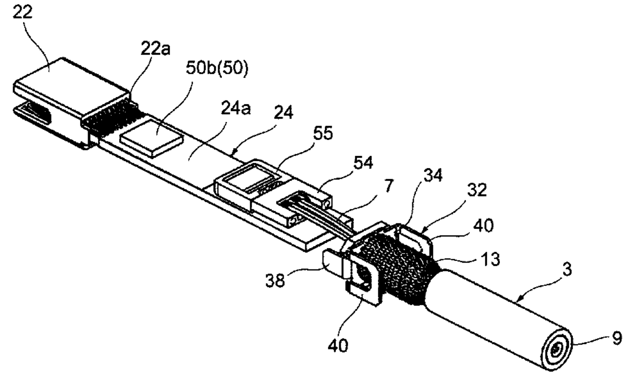
Primary Examiner — Jennifer Doan

(74) *Attorney, Agent, or Firm* — Drinker Biddle & Reath LLP

(57) **ABSTRACT**

An optical module (**1**) of the invention includes a circuit substrate (**24**) on which light receiving and emitting elements (**52**) are mounted, a connector component (**54**) for holding optical fibers (**7**), and a lens array component (**55**) which is fixed on the circuit substrate (**24**) and optically connects the optical fibers (**7**) to the light receiving and emitting elements (**52**) on the circuit substrate (**24**), and the circuit substrate (**24**) has a lens array mounting region (A**1**) in which the lens array component (**55**) is fixed and a connector component opposed region (A**2**) opposed to the connector component (**54**), and thermal insulation space is formed between the connector component (**54**) and the connector component opposed region (A**2**).

9 Claims, 13 Drawing Sheets



(52) **U.S. Cl.**
CPC ***G02B 6/4273*** (2013.01); ***G02B 6/4284*** (2013.01); *G02B 6/3885* (2013.01); *G02B 6/423* (2013.01); *G02B 6/4214* (2013.01); *G02B 6/4246* (2013.01)

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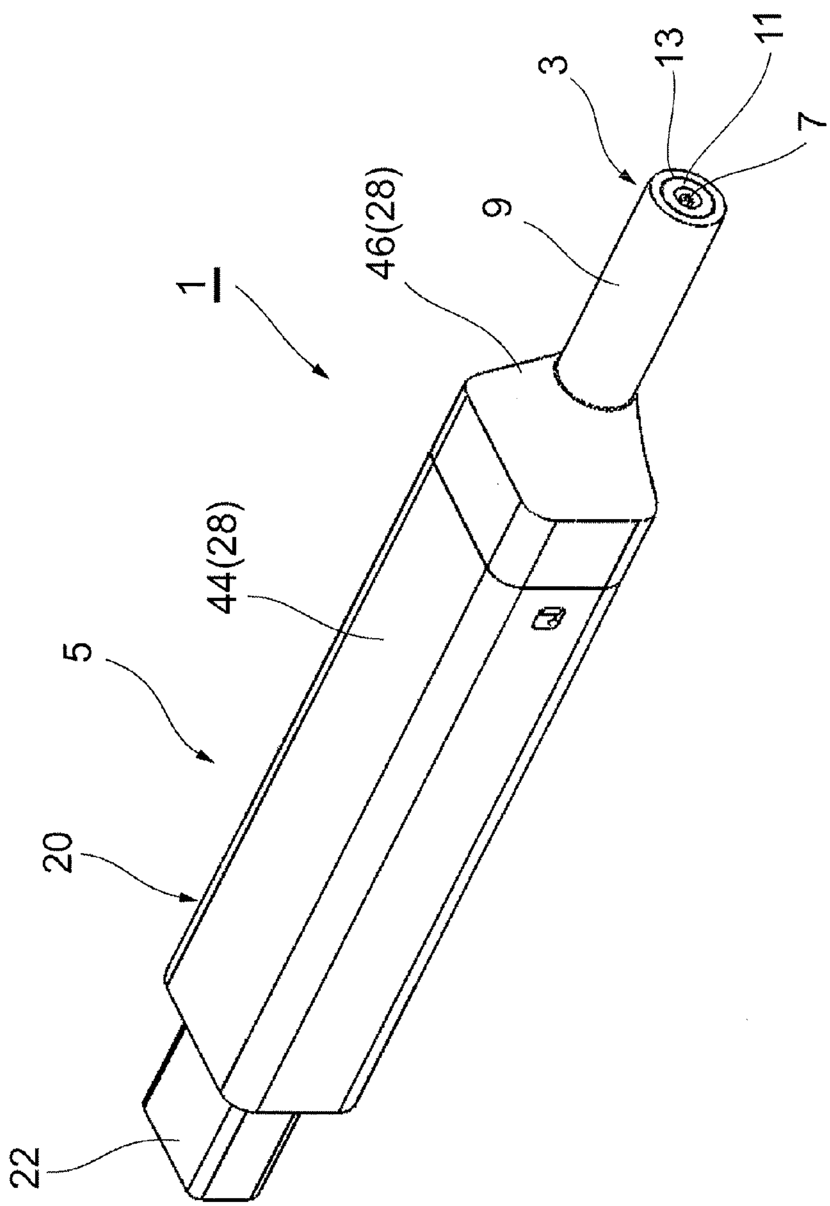


FIG.1

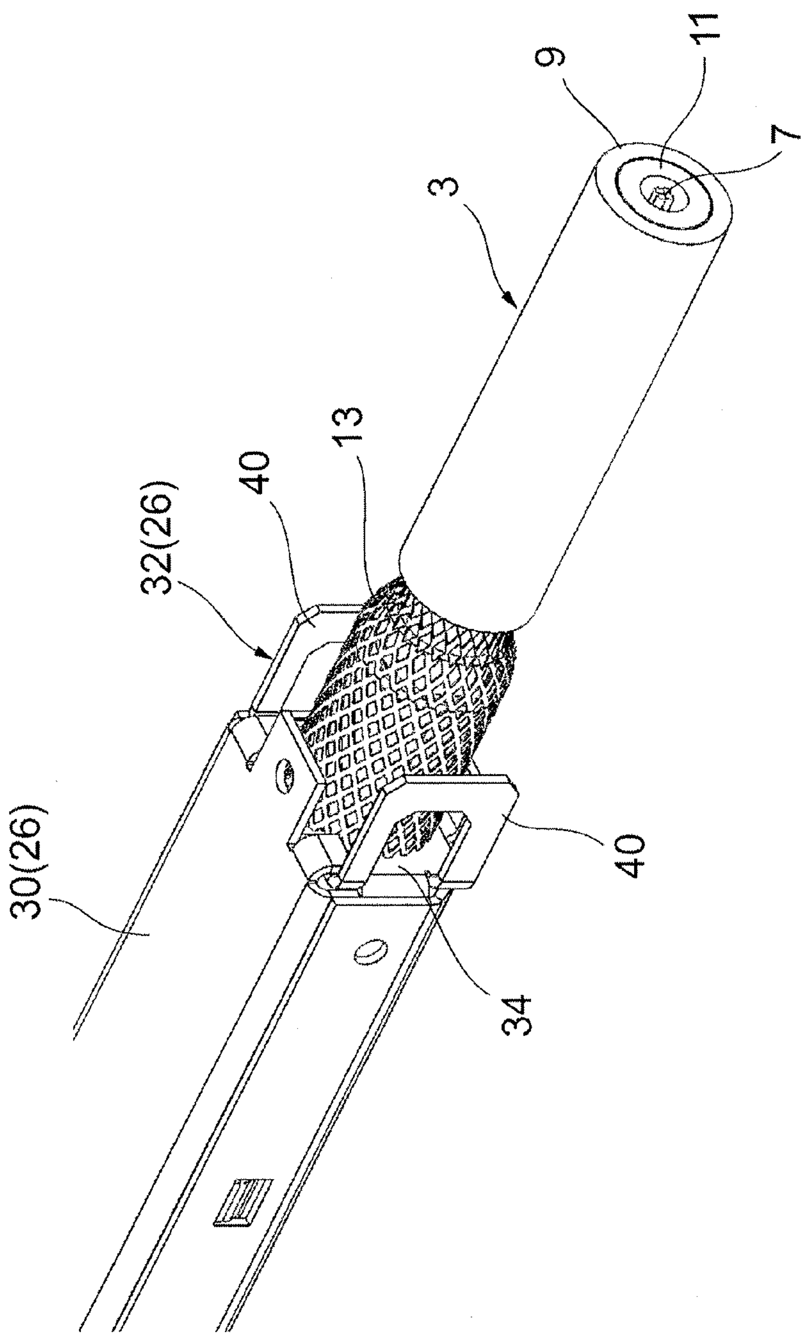


FIG.2

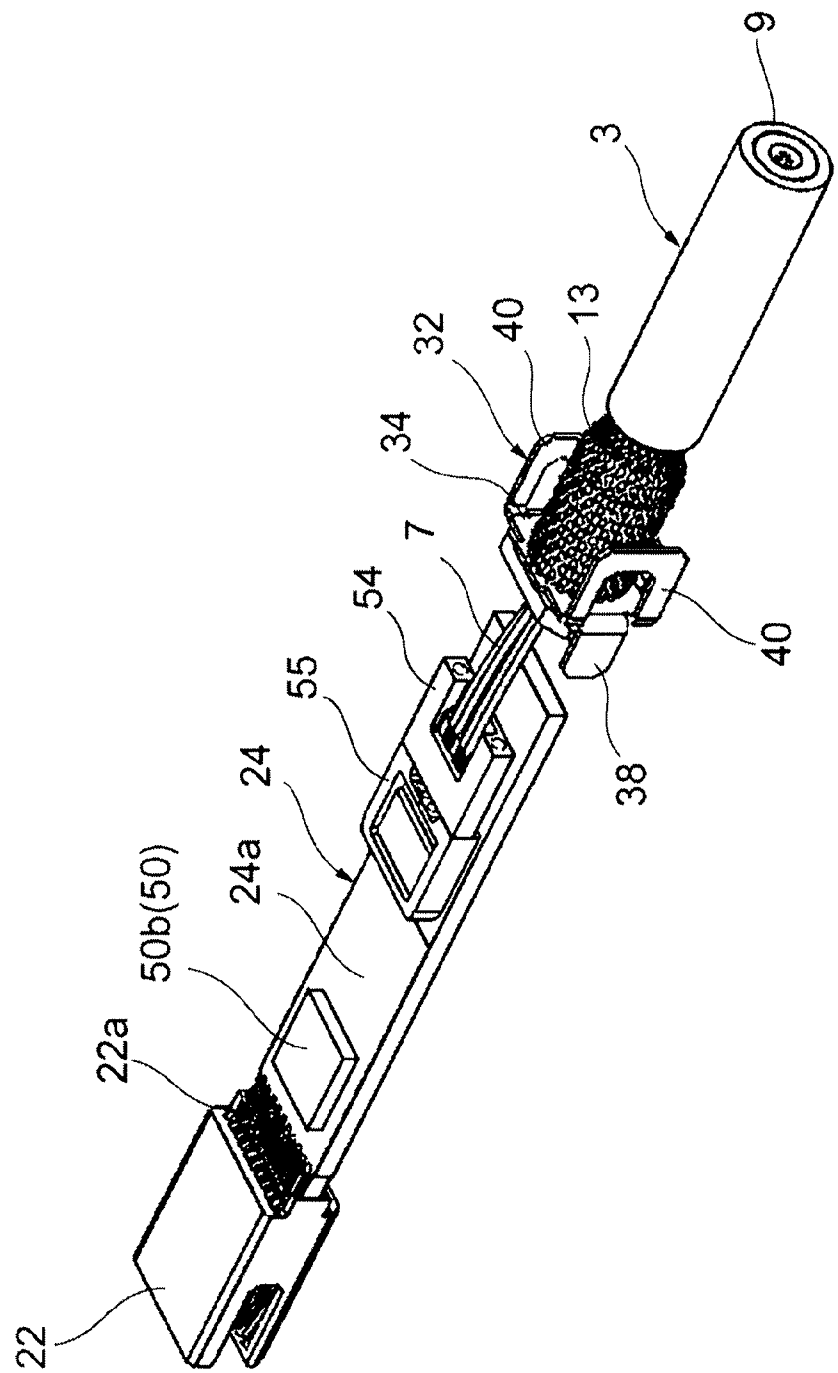


FIG.3

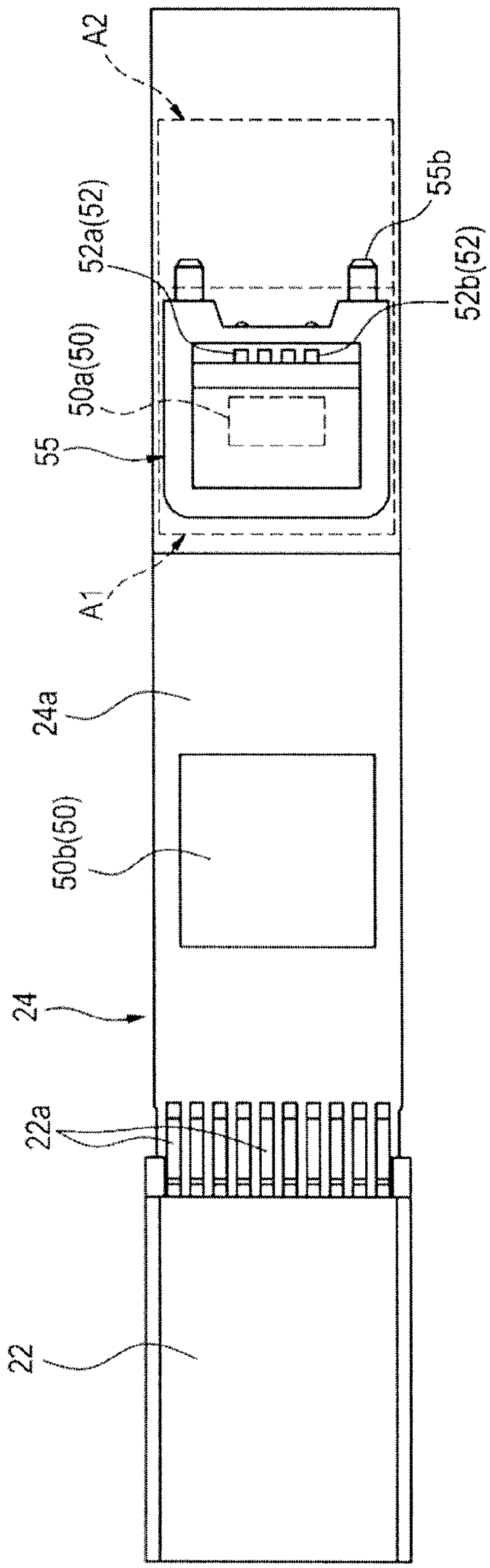


FIG.4A

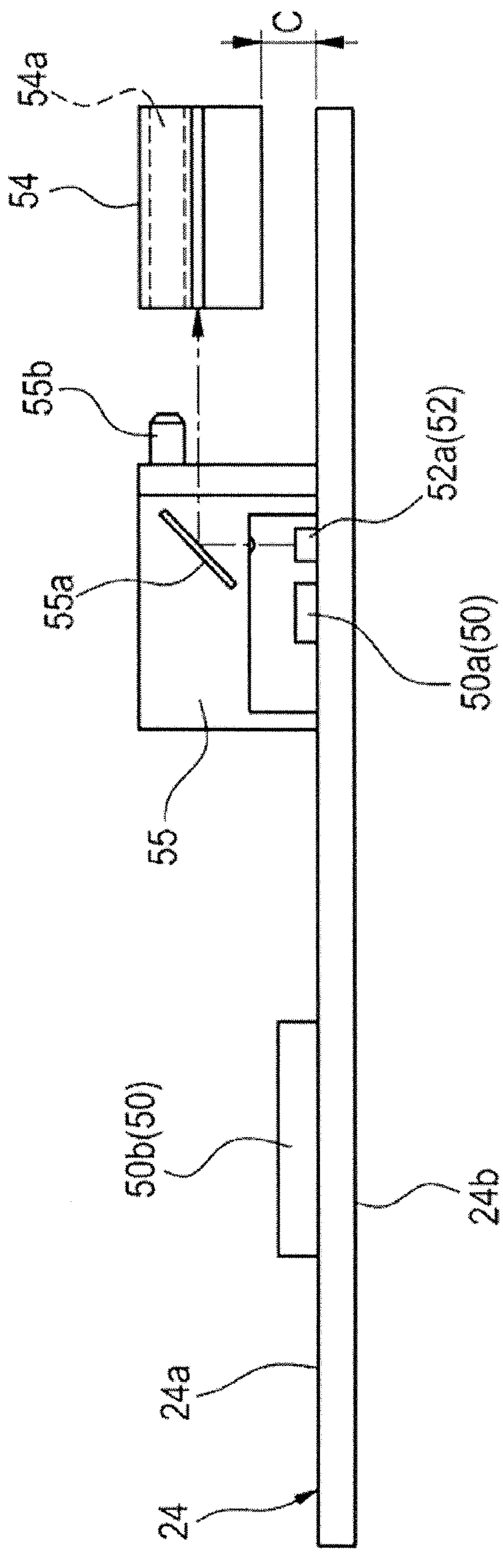


FIG.4B

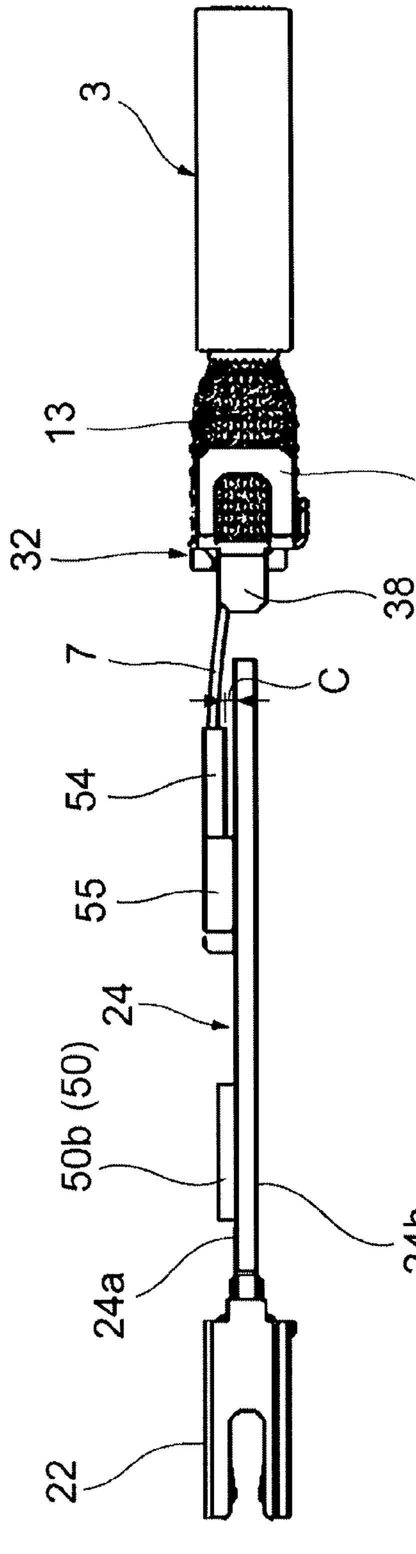


FIG.5

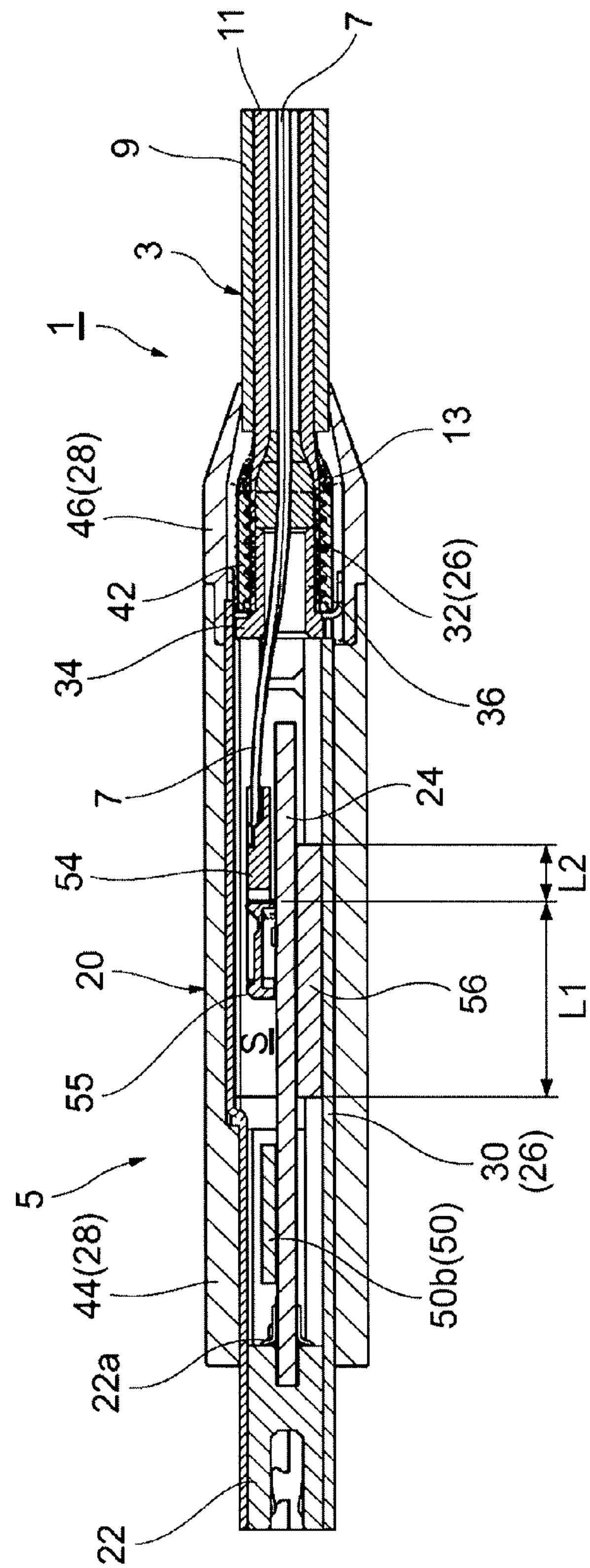
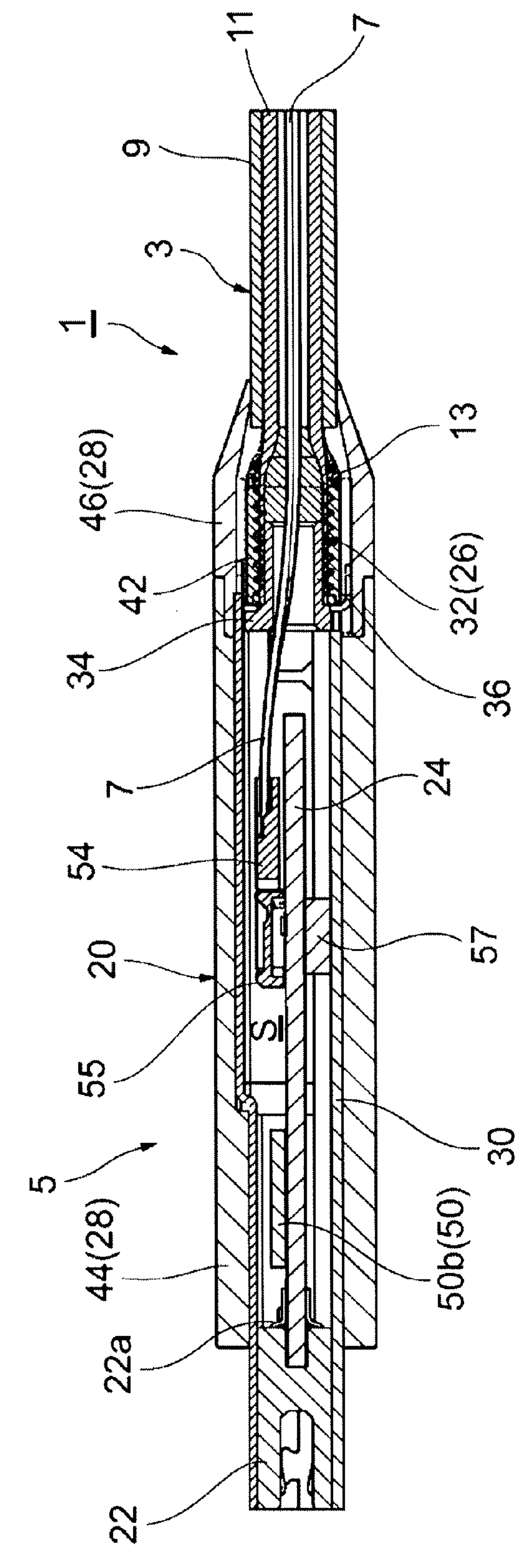

11
7
9
3
1
46(28)
13
42
32(26)
34
36
7
24
54
L2
20
56
L1
55
S
30
(26)
5
44(28)
50b(50)
22a
22

FIG.6


11
7
9
3
1
13
46(28)
42
32(26)
34
36
7
24
54
57
20
55
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44(28)
50b(50)
22a
22

FIG.7

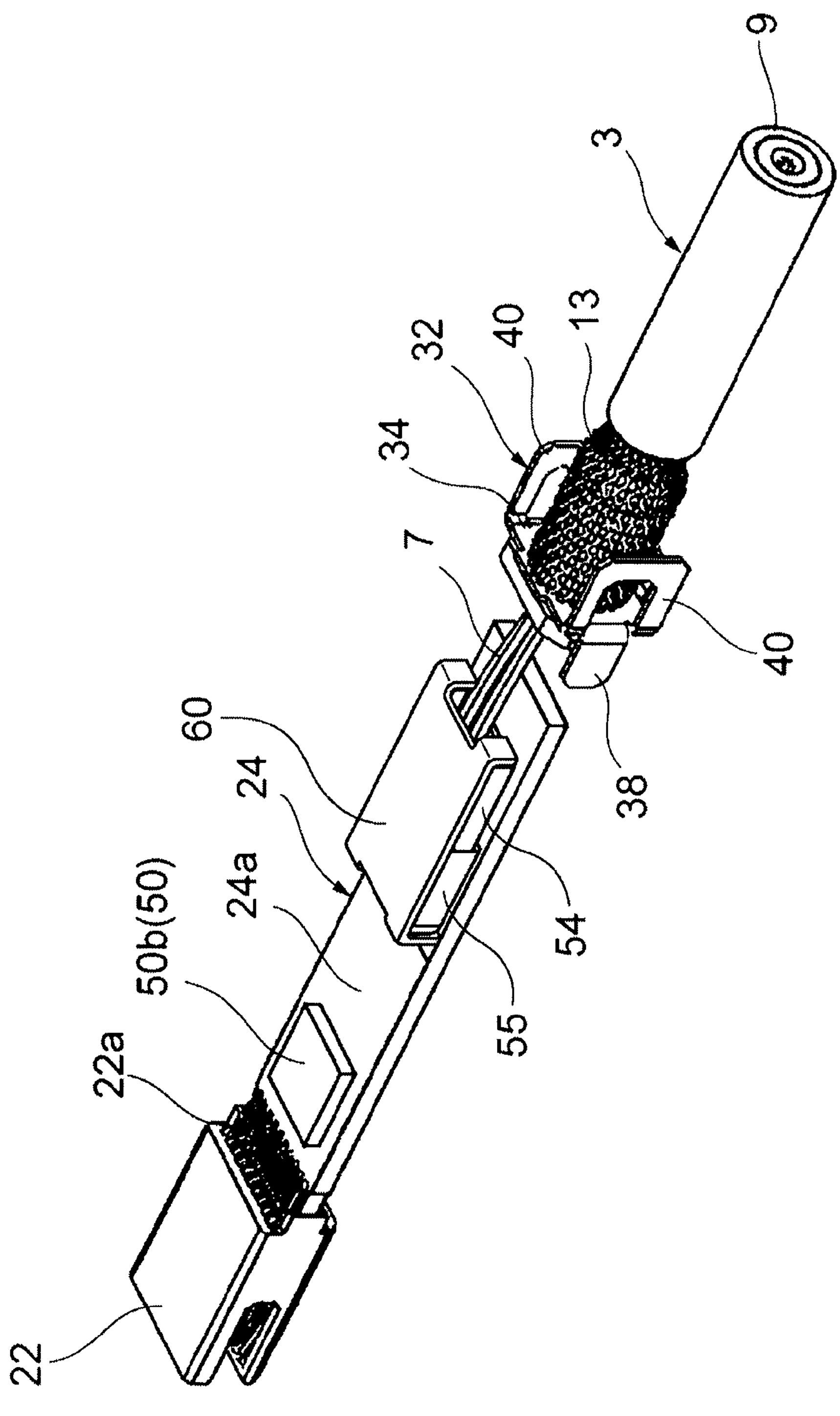


FIG.8

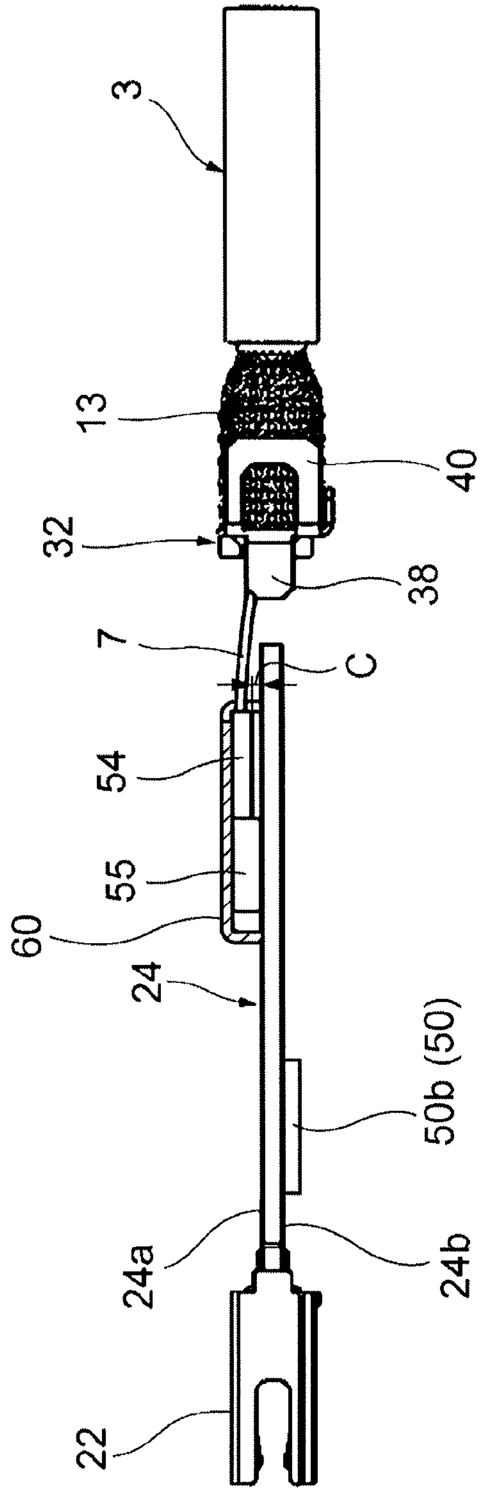


FIG.9

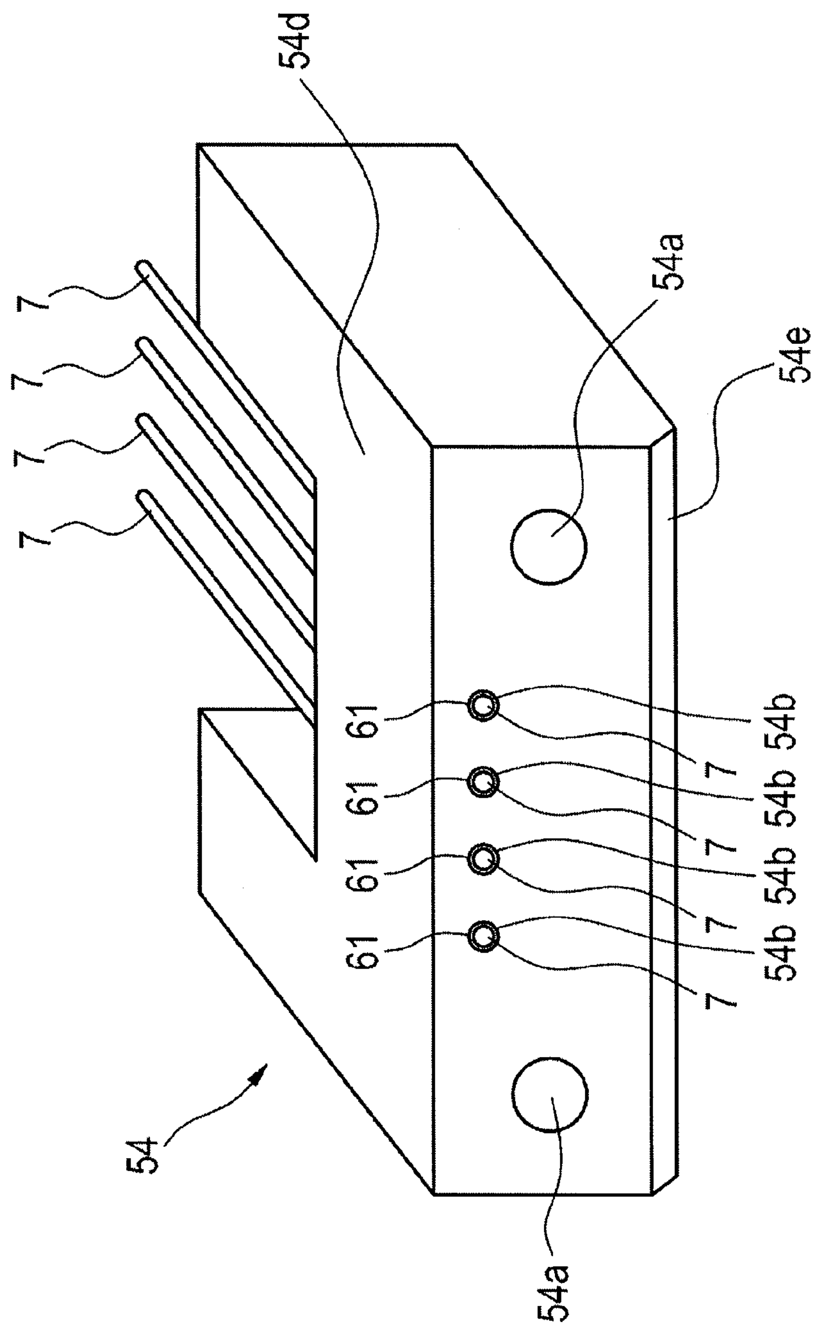
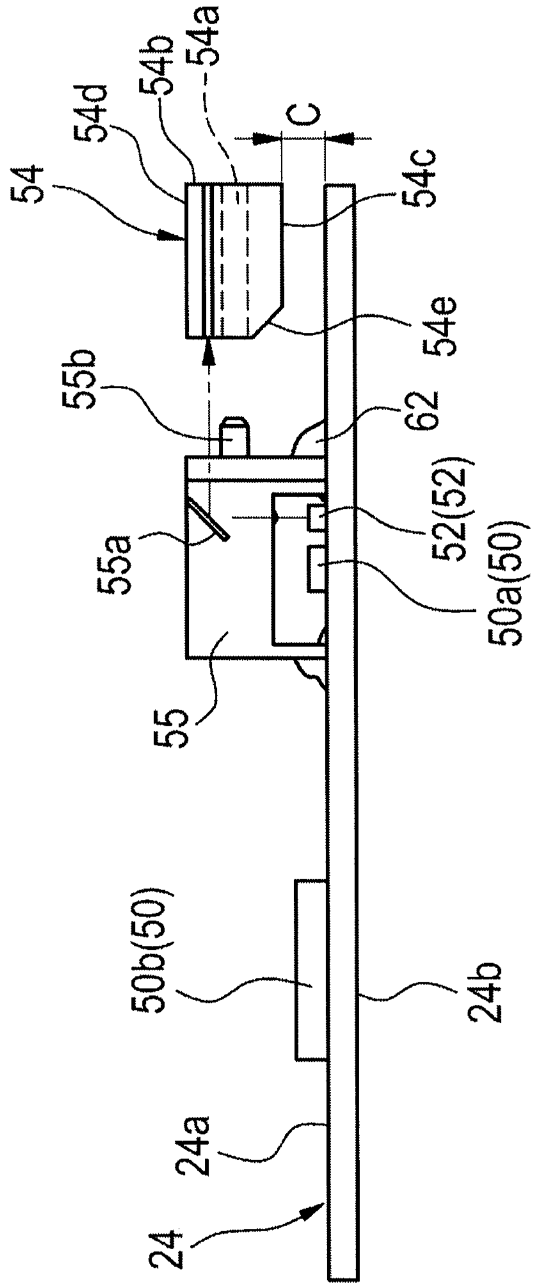


FIG.10


54
54d
54b
54a
C
54c
54e
55b
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52(52)
55a
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55
50b(50)
24b
24a
24

FIG.11

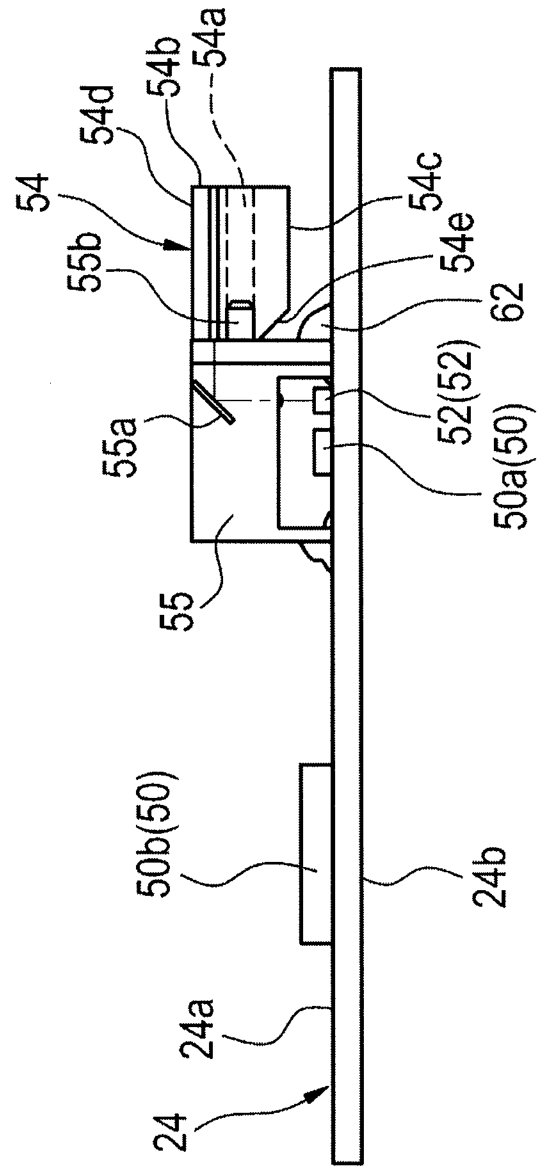

FIG.12

OPTICAL MODULE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a National Stage Application of PCT/JP2012/083058, filed Dec. 20, 2012, which claims the benefit of Japanese Patent Application No. 2011-289052, the contents of which are incorporated herein by reference.

TECHNICAL FIELD

The present invention relates to an optical module including a circuit substrate on which an optical element is mounted.

BACKGROUND ART

In recent years, an optical module used in network equipment is becoming more multichannel, higher in speed and smaller in size. One example of the optical module adapted to become more multichannel, higher in speed and smaller in size is an optical module including the optical element including a photo detector and a light emitter and a light emitting element formed on a circuit substrate, a lens block having a lens facing to the optical element, and a ferrule connected to the lens block, the ferrule in which an optical fiber is inserted (see Patent Document 1).

Patent Document 1: JP-A-2010-122312

When the inside of the optical module is provided with a photoelectric conversion part for converting an electrical signal into an optical signal, it is necessary to design the whole module in consideration of heat generated in the photoelectric conversion part. On the other hand, workability of an assembly process of assembling the module is also one important problem.

In the optical module disclosed in Patent Document 1, the lens block is mounted in the end of the circuit substrate and a protrusion formed on the ferrule is inserted into a hole bored in the lens block to thereby connect both members. However, since this configuration does not have a region in which the ferrule is mounted on the circuit substrate, insertion work of the ferrule cannot be done along the circuit substrate and workability decreases. Also, when an assembly worker accidentally applies a force vertical to a connection direction to the ferrule after connection between both members, the protrusion formed on the ferrule may break.

Hence, in the optical module of Patent Document 1, it is contemplated to extend the end of the circuit substrate to a predetermined region in which the ferrule is mounted and support the ferrule by a part of the circuit substrate. However, in this configuration, heat generated in the photoelectric conversion part concentrates on the lens block or the ferrule. Then, since the lens block differs from the ferrule in a thermal expansion coefficient, different thermal stresses are applied to the lens block and the ferrule. When the different thermal stresses are applied to the portion of bonding between the lens block and the ferrule, unexpected variations are given to the portion of optical coupling between the lens block and the ferrule, and communication quality may deteriorate.

An object of the invention is to provide an optical module capable of reducing an influence of heat generated in a photoelectric conversion part while ensuring workability at the time of assembly.

SUMMARY

In order to achieve the object described above, an optical module of the invention is an optical module including a circuit substrate on which an optical element is mounted; an optical fiber holding member for holding an optical fiber; and an optical coupling member which is fixed on the circuit substrate and optically connects the optical fiber to the optical element on the circuit substrate, wherein the circuit substrate has a first region in which the optical coupling member is fixed and a second region opposed to the optical fiber holding member, and a thermal insulation space is formed between the optical fiber holding member and the second region.

Also in the optical module of the invention, preferably, the optical coupling member is fixed to the circuit substrate by an adhesive and a first connecting part is formed on the optical coupling member, and a second connecting part connected to the first connecting part and an optical fiber holding hole into which the optical fiber is inserted are formed in the optical fiber holding member, and the optical fiber is fixed to the optical fiber holding hole by an adhesive, the optical fiber holding member has a first surface and a second surface, the second surface is formed opposite to the first surface, and the first surface is opposed to the thermal insulation space, and in a state in which the optical coupling member is connected to the optical fiber holding member by the first connecting part and the second connecting part, the optical fiber holding hole is formed at a position which is more distant from the circuit substrate than a position at which the second connecting part is formed in the second surface.

Also in the optical module of the invention, preferably, the circuit substrate has a first mounting surface on which the optical element is mounted and a second mounting surface opposite to the first mounting surface, and a heat conducting member is mounted on the second mounting surface of the circuit substrate, and the heat conducting member has a first heat conducting portion in the first region of the second mounting surface and a second heat conducting portion in the second region of the second mounting surface, and an area of the first heat conducting portion is larger than an area of the second heat conducting portion.

Also in the optical module of the invention, the heat conducting member may be configured to be formed in the first region of the second mounting surface and be not formed in the second region of the second mounting surface.

Also in the optical module of the invention, the heat conducting member is preferably formed in the first region of the second mounting surface and is provided so as to extend to a side opposite to the second region.

Also in the optical module of the invention, an electronic component with a heating value higher than that of the optical element is preferably mounted on the circuit substrate in a region opposite to the second region with respect to the first region.

Also in the optical module of the invention, the electronic component is preferably mounted on the second mounting surface of the circuit substrate.

Also, the optical module of the invention preferably includes a clip member for mechanically joining the optical coupling member to the optical fiber holding member.

Also in the optical module of the invention, preferably, the clip member is a member with thermal conductivity higher than that of the optical fiber holding member, and the clip member makes contact with at least a part of the second surface of the optical fiber holding member.

According to the optical module of the invention, the optical module capable of reducing an influence of heat generated in a photoelectric conversion part while ensuring workability at the time of assembly can be provided.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view showing an optical module according to a first embodiment.

FIG. **2** is a perspective view showing a state in which a resin housing is detached.

FIG. **3** is a perspective view showing a state in which a metal housing is detached.

FIG. **4**A is a view seeing a substrate shown in FIG. **3** from above.

FIG. **4**B is a view seeing the substrate shown in FIG. **3** from the lateral side.

FIG. **5** is a view seeing a circuit substrate and a fixing member shown in FIG. **3** from the lateral side.

FIG. **6** is a sectional view of the optical module shown in FIG. **1**.

FIG. **7** is a view showing a modified example of a heat conducting sheet shown in FIG. **6**.

FIG. **8** is a perspective view showing a modified example having a clip member.

FIG. **9** is a view seeing a circuit substrate and an electronic component on the circuit substrate shown in FIG. **8** from the lateral side.

FIG. **10** is a perspective view showing a connector component used in an optical module according to a second embodiment.

FIG. **11** is a view seeing a substrate of the optical module according to the second embodiment from the lateral side.

FIG. **12** is a view seeing the substrate of the optical module according to the second embodiment from the lateral side.

DETAILED DESCRIPTION

Preferred embodiments of the invention will hereinafter be described in detail with reference to the accompanying drawings. In addition, in explanation of the drawings, the same numerals are assigned to the same or equivalent elements and the overlap explanation is omitted.

First Embodiment

First, an optical module according to a first embodiment will be described. An optical module **1** shown in FIG. **1** is used for transmitting a signal (data) in optical communication technology etc., and is electrically connected to an electronic device such as a personal computer of a connection destination and converts inputted and outputted electrical signals into optical signals and transmits the optical signals.

As shown in FIG. **1**, the optical module **1** includes an optical cable **3** and a connector module **5**. The optical module **1** is configured to attach the distal end of the single-core or multi-core optical cable **3** to the connector module **5**.

The optical cable **3** has plural (four herein) optical fibers **7**, a resin-made outer sheath **9** for covering the optical fibers **7**, an ultrathin-diameter tensile strength fiber (Kevlar) **11** interposed between the optical fibers **7** and the outer sheath **9**, and a metal braid **13** interposed between the outer sheath **9** and the tensile strength fiber **11** as shown in FIGS. **1** to **3**. In other words, in the optical cable **3**, the optical fibers **7**, the tensile strength fiber **11**, the metal braid **13** and the outer sheath **9** are arranged in this order from the center of the optical cable **3** toward the radial outside.

As the optical fibers **7**, an optical fiber in which a core and cladding are made of quartz glass (AGF: All Glass Fiber), an optical fiber in which cladding is made of hard plastic (HPCF: Hard Plastic Clad Fiber), etc. can be used. In the case of using the HPCF with a small diameter in which a core diameter of glass is 80 μm, the HPCF is resistant to fracture even when the optical fibers **7** is bent in a small diameter. The outer sheath **9** is formed of, for example, PVC (polyvinylchloride) which is a halogen-free flame-retardant resin. An outside diameter of the outer sheath **9** is about 4.2 mm, and thermal conductivity of the outer sheath **9** is, for example, 0.17 W/m·K. The tensile strength fiber **11** is, for example, an aramid fiber, and is built into the optical cable **3** in a state gathered in a bundle shape.

The metal braid **13** is formed of, for example, a tin-plated conductive wire, and a braid density is 70% or more, and a knitting angle is 45° to 60°. An outside diameter of the metal braid **13** is about 0.05 mm. Thermal conductivity of the metal braid **13** is, for example, 400 W/m·K. The metal braid **13** is preferably arranged in a high density in order to well ensure thermal conduction, and is preferably constructed of a tin-plated conductive wire of a rectangular wire by way of example.

The connector module **5** includes a housing **20**, an electrical connector **22** formed on the front end (distal end) side of the housing **20**, and a circuit substrate **24** received in the housing **20**.

The housing **20** includes a metal housing (first housing) **26** and a resin housing (second housing) **28**. The metal housing **26** includes a receiving member **30**, and a fixing member **32** which is joined to the back end of the receiving member **30** and fixes the optical cable **3**. The metal housing **2 6** is formed of a metal material with high thermal conductivity (preferably, 100 W/m·K or more), for example, steel (Fe series), tin (tin-plated copper), stainless steel, copper, brass or aluminum. The metal housing **26** constructs a thermal conductor.

The receiving member **30** is a tubular hollow member whose cross section shows substantially a rectangular shape. The receiving member **30** defines receiving space S for receiving the circuit substrate **24** etc. The front end side of the receiving member **30** is provided with the electrical connector **22**, and the fixing member **32** is joined to the back end side of the receiving member **30**.

The fixing member **32** has a plate-shaped basal part **34**, a tubular part **36**, a pair of first overhanging pieces **38** forward overhanging from both sides of the basal part **34**, and a pair of second overhanging pieces **40** backward overhanging from both sides of the basal part **34**. The pair of first overhanging pieces **38** is respectively inserted from the back of the receiving member **30**, and abuts on and is joined to the receiving member **30**. The pair of second overhanging pieces **40** is joined to a boot **46** of the resin housing **28** described below. In addition, in the fixing member **32**, the basal part **34**, the tubular part **36**, the first overhanging pieces **38** and the second overhanging pieces **40** are integrally formed by sheet metal.

The tubular part **36** has substantially a cylindrical shape and is formed so as to backward project from the basal part **34**. The tubular part **36** holds the optical cable **3** in cooperation with a crimp ring **42**. Concretely, after the outer sheath **9** is peeled, the optical fibers **7** of the optical cable **3** are inserted into the tubular part **36** and also the tensile strength fiber **11** is arranged along an outer peripheral surface of the tubular part **36**. Then, the crimp ring **42** is arranged on the tensile strength fiber **11** arranged on the outer peripheral surface of the tubular part **36**, and the crimp ring **42** is crimped. Accordingly, the tensile strength fiber **11** is fixed by being pinched between the tubular part **36** and the crimp ring **42**, and the optical cable **3** is held and fixed to the fixing member **32**.

The end of the metal braid **13** of the optical cable **3** is bonded to the basal part **34** by solder. Concretely, the metal braid **13** is arranged so as to cover the outer periphery of the crimp ring **42** (tubular part **36**) in the fixing member **32**, and the end of the metal braid **13** is extended to one surface (back surface) of the basal part **34** and is bonded by solder.

Accordingly, the metal braid **13** is thermally connected to the fixing member **32**. Further, by coupling the fixing member **32** to the back end of the receiving member **30**, the fixing member **32** is physically and thermally connected to the receiving member **30**. In other words, the metal braid **13** of the optical cable **3** is thermally connected to the receiving member **30**.

The resin housing **28** is formed of a resin material such as polycarbonate, and covers the metal housing **26**. The resin **12** housing **28** has an exterior housing **44**, and the boot **46** joined to the exterior housing **44**. The exterior housing **44** is formed so as to cover an outer surface of the receiving member **30**. The boot **46** is joined to the back end of the exterior housing **44**, and covers the fixing member **32** of the metal housing **26**. The back end of the boot **46** is glued to the outer sheath **9** of the optical cable **3** by an adhesive (not shown).

The electrical connector **22** is the portion inserted into a connection target (a personal computer etc.) and electrically connected to the connection target. The electrical connector **22** is arranged in the front end side of the housing **20**, and forward projects from the housing **20**. The electrical connector **22** is electrically connected to the circuit substrate **24** by a contact **22***a*.

The circuit substrate **24** is received in the receiving space S of the metal housing **26** (receiving member **30**). A semiconductor **50** for control and light receiving and emitting elements **52** are mounted on the circuit substrate **24**. The circuit substrate **24** electrically connects the semiconductor **50** for control and the light receiving and emitting elements **52**. The circuit substrate **24** shows substantially a rectangular shape in plan view, and has a predetermined thickness. The circuit substrate **24** is, for example, an insulating substrate such as a glass epoxy substrate or a ceramic substrate, and circuit wiring is formed on the surface of or inside the circuit substrate **24** by, for example, gold (Au), aluminum (Al) or copper (Cu). The semiconductor **50** for control and the light receiving and emitting elements **52** construct a photoelectric conversion part.

The semiconductor **50** for control includes a driving IC (Integrated Circuit) **50***a*, a CDR (Clock Data Recovery) device SOb which is a waveform shaper, etc. The semiconductor **50** for control is arranged in the front end side of a front surface **24***a* (one example of a first mounting surface) in the circuit substrate **24**. The semiconductor **50** for control is electrically connected to the electrical connector **22**.

As shown in FIG. **4**A and FIG. **4**B, the light receiving and emitting elements **52** are configured to include plural (two herein) light emitting elements **52***a* and plural (two herein) light receiving elements **52***b*. The light emitting elements **52** a and the light receiving elements **52***b* are arranged in the back end side of the front surface **2 4***a* in the circuit substrate **24**. As the light emitting element **52** a, for example, a light emitting diode (LED), a laser diode (LD) or a vertical cavity surface emitting laser (VCSEL) can be used. As the light receiving element **52***b*, for example, a photo diode (PO) can be used.

The light receiving and emitting elements **52** are optically connected to the optical fibers **7** of the optical cable **3**. Concretely, as shown in FIG. **4**B, a lens array component **55** (one example of an optical coupling member) is arranged on the circuit substrate **24** so as to cover the light receiving and emitting elements **52** and the driving IC **50***a*. A reflector **55***a* for reflecting and bending light emitted from the light emitting element **52***a* or light emitted from the optical fibers **7** is arranged in the lens array component **55**. A connector component **54** (one example of an optical fiber holding member) is attached to the distal end of the optical fibers **7** (not shown in FIG. **4**A and FIG. **4**B), and a positioning pin **55***b* is fitted into a positioning hole **54***a* to thereby position and couple the lens array component **55** to the connector component **54**, and the light receiving and emitting elements **52** are optically connected to the optical fibers **7**.

Also in the embodiment described above, as shown in FIG. **4**B, the light receiving and emitting elements **52** and the optical fibers **7** have different optical axes, and optical axis directions are converted so that the light receiving and emitting elements **52** are optically coupled to the optical fibers **7** by the reflector **55***a* of the lens array component **55** which is the optical coupling member. Also, the positioning pin **55***b* formed on the lens array component **55** is formed so as to project in a direction substantially parallel to the optical axis of the optical fibers **7**. The connector component **54** for holding the optical fibers **7** is moved in the direction substantially parallel to the optical axis of the optical fibers **7** and thereby, the positioning pin **55***b* of the lens array component **55** is fitted into the positioning hole **54***a* of the connector component **54** and the light receiving and emitting elements **52** are optically coupled to the optical fibers **7**. Since a projection direction of the positioning pin **55***b* is substantially parallel to a surface direction of the circuit substrate **24**, the connector component **54** can be connected along the front surface of the circuit substrate **24** and efficiency (workability) of assembly work improves.

The lens array component **55** preferably includes collimation lenses for collimating incident light and collecting and emitting the parallel light in an incoming part and an outgoing part of light. Such a lens array component **55** can be integrally constructed by injection molding of resin. The lens array component **55** and the connector component **54** are formed of different materials and have mutually different thermal expansion coefficients.

Also, as shown in FIG. **4**A, the circuit substrate **24** has a lens array mounting region A**1** (one example of a first region) in which the lens array component **55** is mounted, and a connector component opposed region A**2** (one example of a second region) to which the connector component **54** is opposed. As shown in FIG. **4**B, a thermal insulation space having a predetermined distance C is formed between the connector component **54** and the connector component opposed region A**2**. As shown in FIG. **5**, this thermal insulation space is ensured even in a state in which the lens array component **55** is connected to the connector component **54**.

The lens array component **55** is preferably constructed of a resin (for example, a polyetherimide resin: a linear expansion coefficient of 5.6×10-5/K) having high dimension accuracy in molding and high transparency to communication light, and further in the case of assuming use in a high-temperature environment, the lens array component **55** is constructed of a resin (for example, an electron beam cross-linked resin: a linear expansion coefficient of 9.0×10-5/K) capable of withstanding high-temperature treatment such as reflow and having high transparency to communication light. Also, the connector component **54** is constructed of a material (for example, a polyphenylene sulfide resin: a linear expansion coefficient of 2.6×10-5/K) having high dimension accuracy in molding.

As shown in FIG. **6**, a heat conducting sheet **56** is arranged between the circuit substrate **24** and the receiving member **30** (metal housing **26**). The heat conducting sheet **56** is a thermal conductor formed of material having thermal conductivity and flexibility. The heat conducting sheet **56** is formed so as to cover the whole back side of the lens array mounting region A**1** from the vicinity of the center of the back side of the connector component opposed region A**2** in a back surface **2 4***b* (one example of a second mounting surface and see FIG. **4**B) of the circuit substrate **24** and further extend toward the electrical connector **22**. The heat conducting sheet **56** includes a connector component corresponding portion having a length L**2** ranging from the vicinity of the center of the back side of the connector component opposed region A**2** to one end of the connector component opposed region A**2**, and a lens array component corresponding portion having a length L**1** ranging from one end of the connector component opposed region A**2** to the vicinity near to the back side of the CDR device SOb beyond the whole back side of the lens array mounting region A**1** as shown in FIG. **6**. Since a length of the heat conducting sheet **56** in a width direction is constant, the area in which the lens array component corresponding portion defined by the length L**1** makes contact with the circuit substrate **24** is larger than the area in which the connector component corresponding portion defined by the length L**2** makes contact with the circuit substrate **24**.

Also, in the heat conducting sheet **56**, the upper surface is physically and thermally connected to the back surface **24***b* of the circuit substrate **24** and also the lower surface is physically and thermally connected to the inside surface of the receiving member **30**. By this heat conducting sheet **56**, the circuit substrate **24** is thermally connected to the metal housing **26**, and heat of the circuit substrate **24** is transferred to the receiving member **30**.

In addition, the heat conducting sheet may be formed on only the back side of the lens array mounting region A**1** like a heat conducting sheet **57** shown in FIG. **7**. That is, it may be constructed so that the heat conducting sheet **57** is not formed on the back side of the connector component opposed region A**2**.

In the optical module **1** having the configuration described above, an electrical signal is inputted from the electrical connector **22**, and the semiconductor **50** for control inputs the electrical signal through wiring of the circuit substrate **24**. In the electrical signal inputted to the semiconductor **50** for control, for example, the level is adjusted or a waveform is shaped by the CDR device **50***b* and thereafter, the electrical signal is outputted from the semiconductor **50** for control to the light receiving and emitting elements **52** through wiring of the circuit substrate **24**. In the light receiving and emitting elements **52** to which the electrical signal is inputted, the electrical signal is converted into an optical signal and the optical signal is emitted from the light emitting element **52***a* to the optical fibers **7**.

Also, an optical signal transmitted by the optical cable **3** enters the light receiving element **52***b*. In the light receiving and emitting elements **52**, the entering optical signal is converted into an electrical signal and this electrical signal is outputted to the semiconductor **50** for control through wiring of the circuit substrate **24**. In the semiconductor **50** for control, the electrical signal is outputted to the electrical connector **22** after predetermined processing is performed on the electrical signal.

Subsequently, a heat conducting method in the optical module **1** will be described with reference to FIG. **6**. Heat generated in the semiconductor **50** for control and the light receiving and emitting elements **52** mounted on the circuit substrate **24** is first transferred to the circuit substrate **24**. The heat transferred to the circuit substrate **2 4** is transferred to the receiving member **30** through the heat conducting sheet **56**. Next, the heat is transferred from the receiving member **30** to the fixing member **32** joined to the receiving member **30**, and is transferred to the metal braid **13** of the optical cable **3** connected to the fixing member **32**. Then, the heat transferred to the fixing member **32** is radiated to the outside through the outer sheath **9** of the optical cable **3**. As described above, in the optical module **1**, the heat generated in the semiconductor **50** for control and the light receiving and emitting elements **52** which are heating elements is radiated to the outside.

In the present embodiment as described above, the circuit substrate **24** has the lens array mounting region A**1** in which the lens array component **55** is mounted and the connector component opposed region A**2** to which the connector component **54** is opposed. Consequently, at the time of assembly work, a sudden force can be prevented from being applied to the connector component **54** by the circuit substrate **24**. Also, even when a sudden force is applied after the lens array component **55** is bonded to the connector component **54**, the circuit substrate **24** makes contact with the connector component **54** to make support and thereby, the portion of bonding between the lens array component **55** and the connector component **54** can be prevented from being damaged. Also, when the connector component **54** is connected to the lens array component **55**, the connector component **54** can be connected along the connector component opposed region A**2** of the circuit substrate **24**, so that efficiency (workability) of assembly work improves.

Also, a thermal insulation space having the predetermined distance C is formed between the connector component opposed region A**2** and the connector component **54** connected to the lens array component **55**. In this thermal insulation space, heat generated from the light receiving and emitting elements **52** in the case of photoelectric conversion is not transferred from the circuit substrate **24** to the connector component **54** directly, and a part of the connector component **54** is supported in a state separated from the circuit substrate **24** by a predetermined distance so as not to abut on the circuit substrate **24**. Also, the heat generated from the light receiving and emitting elements **52** can be lost from the thermal insulation space. From the standpoint of reducing damage to the positioning pin **55***b* from an external force and workability of connection between the lens array component **55** and the connector component **54** while having such an effect, the predetermined distance C of the thermal insulation space is preferably about 50 μm to 300 μm, more preferably about 50 μm to 100 μm. Thus, an optical connection state can be prevented from varying due to deviation of a position of an end face of the optical fibers **7** from a lens part of the lens array component **55** when the lens array component **55** and the connector component **54** thermally expand.

That is, since the lens array component **55** and the connector component **54** have different thermal expansion coefficients, when both of the components change to a high-temperature state in the case of fixing the connector component **54** to the circuit substrate **24**, a stress may be caused on a surface of bonding between both of the components to damage the surface of bonding. However, since the embodiment has the configuration (configuration having the thermal insulation space) in which the connector component **54** does not make contact with the connector component opposed region A**2** of the circuit substrate **24**, the stress due to thermal expansion of the connector component **54** can be prevented from concentrating on the surface of bonding.

Also, in the embodiment, the case of positioning and coupling the connector component **54** and the lens array component **55** by the positioning pin is described, but a clip member **60** for fixing and supporting the connector component **54** and the lens array component **55** while pinching the components **54** and **55** as shown in FIG. **8** or **9** may be formed in order to ensure the thermal insulation space by the predetermined distance C. The clip member **60** is a member formed by folding both ends of a rectangular metal piece, and is also a member for covering while making close contact with the back parts (the surface opposite to the surface opposed to the circuit substrate) of the connector component **54** and the lens array component **55**. According to this configuration, a state of connection between the connector component **54** and the lens array component **55** can surely be held even when the connector component **54** is not fixed to the circuit substrate **24**.

In the embodiment, the heat conducting sheet **56** has the lens array component corresponding portion (one example of a first heat conducting portion) defined by the length L**1** and the connector component corresponding portion (one example of a second heat conducting portion) defined by the length L**2**, and the area of contact between the lens array component corresponding portion and the circuit substrate **24** is larger than the area of contact between the connector component corresponding portion and the circuit substrate **24**. Also, the heat conducting sheet **56** is formed so as to extend in a direction (a separated direction) opposite to the connector component opposed region A**2**. Consequently, heat generated by the light receiving and emitting elements **52** in the lens array mounting region A**1** is largely radiated in the lens array component corresponding portion of the heat conducting sheet **56** through the circuit substrate **24**, and is not transferred to the connector component corresponding portion too much, and it becomes easy to thermally separate the lens array mounting region A**1** from the connector component opposed region A**2**.

In addition, the heat conducting sheet **56** described in the embodiment is one example and, for example, may have a shape in which the heat conducting sheet is not formed on the back side of the connector component opposed region A**2**. Also, the heat conducting sheet **57** formed on only the back side of the lens array mounting region A**1** in which the lens array component **55** is mounted may be used as shown in FIG. **7**. The heat conducting sheet is constructed so as not to be formed on the back side of the connector component opposed region A**2** and thereby, it becomes easy to thermally separate the lens array mounting region A**1** from the connector component opposed region A**2** in the circuit substrate **24**.

Also, in the embodiment, the semiconductor **50** for control including the CDR device **50***b* is mounted on the circuit substrate **24** in a region opposite to the connector component opposed region A**2** with respect to the lens array mounting region A**1** as shown in FIG. **3**. The CDR device **50***b* (one example of an electronic component) is a component with a heating value higher than that of the light receiving and emitting elements **52** and as described above, the CDR device **50***b* is mounted in the side opposite to the connector component opposed region A**2** and a distance between the CDR device **50***b* and the connector component **54** is ensured and thereby, heat generated in the CDR device **50***b* is configured to be largely lost to the side of the electrical connector **22**. Hence, it becomes easy to thermally separate the lens array mounting region A**1** from the connector component opposed region A**2** in the circuit substrate **24**.

In addition, in the CDR device SOb, the back surface of the circuit substrate **24** may be provided with the CDR device SOb as shown in FIG. **8** or **9**. By providing the back surface of the circuit substrate **24** with the CDR device SOb, a large amount of heat generated in the CDR device SOb is radiated to the side of the electrical connector **22** or the back surface side of the circuit substrate **24**. Consequently, it becomes easy to thermally separate the lens array mounting region A**1** from the connector component opposed region A**2**.

Second Embodiment

Next, an optical module according to a second embodiment will be described. As shown in FIGS. **10** to **12**, optical fiber

holding holes **54***b* into which optical fibers **7** are inserted is formed in a connector component **54**. The optical fibers **7** (not shown in FIGS. **11** and **12**) are inserted into these optical fiber holding holes **54***b*, and the optical fibers are glued and fixed to the optical fiber holding holes **54***b* by adhesives **61**.

A lens array component **55** is fixed to a front surface **24***a* of a circuit substrate **24** by an adhesive. Positioning pins (one example of a first connecting part) **55***b* projecting to the side of the connector component **54** are formed in the vicinity of both lateral parts of this lens array component **55**.

Also, positioning holes (one example of a second connecting part) **54** a are formed along a longitudinal direction in the vicinity of both lateral parts of the connector component **54**. The positioning holes **54***a* are formed in substantially the center in a thickness direction of the connector component **54**, and the positioning pins **55***b* of the lens array component **55** are fitted into the positioning holes **54***a* to thereby make connection.

The connector component **54** has an upper surface (one example of a second surface) **54***d* and a lower surface (one example of a first surface) **54***c*. In each surface constructing the connector component **54**, the upper surface **54***d* is formed opposite to the lower surface **54***c*, and the lower surface **54** is opposed to a thermal insulation space. In a state in which the lens array component **55** is connected to the connector component **54** by the positioning pins **55***b* and the positioning hole **54***a*. In the connector component **54**, in a state in which the lens array component **55** is connected to the connector component **54** by the positioning pins **55***b* and the positioning holes **54***a*, the optical fiber holding hole **54***b* is formed at a position which is more distant from the circuit substrate **24** than a position at which the positioning holes **54***a* are formed in the second surface. Also, this connector component **54** has a chamfered part **54***e* in which the end of the side of the lens array component **55** in the lower surface **54***c* is chamfered along a width direction.

Here, in an optical module **11** having light receiving and emitting elements **52** which are optical elements, heat generated in a circuit etc. for driving the light receiving and emitting elements **52** is transferred from the circuit substrate **24** to the lens array component **55** fixed to the circuit substrate **24**, and a part of the heat is further transferred to the connector component **54** through the portion of connection between the positioning pins **55***b* of the lens array component **55** and the positioning holes **54***a* of the connector component **54**. This heat may soften or deteriorate the adhesive **61** for fixing the optical fibers **7** to the optical fiber holding hole **54***b* to deviate (change) a position in which the optical fiber holding hole **54***b* holds the optical fibers **7**. When the position of the optical fibers **7** is deviated, a position in which an end face of the optical fibers **7** is connected to a lens portion formed on the lens array component **55** is deviated to cause a loss of optical connection.

Also, when an adhesive for connecting the lens array component **55** to the circuit substrate **24** leaks out as shown by numeral **62** in the lower surface **54***c* of the connector component **54**, the lower surface **54***c* may make contact with this adhesive **62** leaking out. In this case, the adhesive **62** leaking out forms a thermal path for transferring heat from the circuit substrate **24** to the lower surface **54***c* of the circuit substrate **24**, and the side of the lower surface **54***c* of the connector component **54** may change to a high temperature.

On the other hand, there is no fear that the adhesive **62** leaking out of a gap between the lens array component **55** and the circuit substrate **24** makes contact with the upper surface **54***d* of the connector component **54**. Also, since the upper surface **54***d* is exposed to the side opposite to the circuit substrate **24**, it is easy to maintain the upper surface **54***d* in a state of temperature lower than that of side of the lower surface **54***c* of the connector component **54**.

In the optical module **11** according to the second embodiment, the optical fiber holding hole **54***b* is formed in a position nearer to the upper surface **54***d* tending to be maintained in the low temperature state than the positioning hole **54***a*, so that the optical fiber holding hole **54***b* can be inhibited from changing to a high temperature. Consequently, the adhesive **61** for fixing the optical fibers **7** to the optical fiber holding hole **54***b* can be prevented from softening or deteriorating, and a situation in which the end face of the optical fibers **7** is deviated to cause a loss of optical connection can be prevented.

Also, in the optical module **11** according to the second embodiment, the chamfered part **54***e* by chamfering is formed on the end of the side of the lens array component **55** in the lower surface **54***c* of the connector component **54**. By chamfering the end of the side of the lens array component **55** in the lower surface **54***c* of the connector component **55** thus, the adhesive **62** leaking out can be prevented from making contact with the lower surface **54***c* even when the adhesive **62** for connecting the lens array component **55** to the circuit substrate **2 4** leaks out.

Also, the connector component **54** and the lens array component **55** may be pinched to be fixed and supported by a clip member **60** made of a material (for example, stainless steel, copper or aluminum) with high thermal conductivity (see FIGS. **8** and **9**). Thus, the clip member **60** makes contact with at least a part of the upper surface **54***d* of the connector component **54**. Consequently, by a heat conducting effect from the clip member **60**, it becomes easy to maintain the upper surface **54***d* of the connector component **54** at low temperature, and the optical fiber holding hole **54***b* can more efficiently be maintained in a low temperature state.

The invention has been described above in detail with reference to the specific embodiments, but it is apparent to those skilled in the art that various changes or modifications can be made without departing from the spirit and scope of the invention.

For example, the example of providing the side of the optical coupling member with the positioning pin for positioning the optical coupling member and the optical fiber holding member is described, but the side of the optical fiber holding member may be provided with the positioning pin. That is, as long as a positioning structure is formed in both of the members, the concrete form is not limited. When a direction of attachment of the positioning structure is substantially parallel to a surface direction of the circuit substrate in this case, the optical fiber holding member can be connected along the circuit substrate, so that efficiency (workability) of assembly work improves as described above.

Also, the configuration in which the optical coupling member optically couples the optical fiber and the light receiving and emitting elements having different optical axes is not limited to the form of the lens array component **55**. That is, it is not essential to form the reflector **55***a*, and a cave part having the same inclined surface as the reflector may be formed in a position corresponding to the reflector **55***a* of the lens array component **55** to form a reflective surface using a refractive index difference at the interface between air and material of the lens array component **55**. Also, instead of the reflective surface, using an optical ferrule having an arcuate optical fiber holding hole capable of bending an optical fiber in an optical axis direction of light receiving and emitting elements, it may be configured to insert the optical fiber from the side of an optical fiber holding member and bend the optical fiber so as to match an optical axis of the optical fiber with an optical axis of the light receiving and emitting elements (in this case, the optical fiber can be prevented from being bent locally in a position of bonding between both of the members). That is, it is not essential to form the reflector **55***a* in the optical coupling member.

The invention has been described in detail with reference to the specific embodiments, but it is apparent to those skilled in the art that various changes or modifications can be made without departing from the spirit and scope of the invention.

The invention claimed is:

1. An optical module comprising:

a circuit substrate on which an optical element is mounted, the circuit substrate including a first region and a second region;

an optical fiber holding member including an optical fiber holding hole into which an optical fiber is inserted and fixed by a first adhesive;

a lower surface facing the second region of the circuit substrate;

an upper surface opposite to the lower surface;

a second connecting part; and

an optical coupling member which includes a first connecting part connected to the second connecting part and is fixed on the first region of the circuit substrate by a second adhesive and optically connects the optical fiber to the optical element on the circuit substrate and is constructed of a material with a linear expansion coefficient different from that of the optical fiber holding member,

wherein a thermal insulation space is formed between the lower surface of the optical fiber holding member and the second region,

wherein the first connecting part is a positioning pin and the second connecting part is a positioning hole or the first connecting part is the positioning hole and the second connecting part is the positioning pin, and

wherein a center axis of the fiber holding hole is nearer to the upper surface than a center axis of the positioning pin.

2. The optical module according to claim **1**, wherein an end portion of the first surface of the optical fiber holding member nearer to the optical coupling member is chamfered.

3. The optical module according to claim **1**,

wherein the circuit substrate has a first mounting surface on which the optical element is mounted and a second mounting surface opposite to the first mounting surface, and a heat conducting member is mounted on the second mounting surface of the circuit substrate, and the heat conducting member has a first heat conducting portion in the first region of the second mounting surface and a second heat conducting portion in the second region of the second mounting surface, and an area of the first heat conducting portion is larger than an area of the second heat conducting portion.

4. The optical module according to claim **3**, wherein the heat conducting member is formed in the first region of the second mounting surface and is only partially formed in the second region of the second mounting surface.

5. The optical module according to claim **3**, wherein the heat conducting member is formed in the first region of the second mounting surface and is provided so as to extend to a side opposite to the second region of the second mounting surface.

6. The optical module according to claim **1**, wherein an electronic component with a heating value higher than that of the optical element is mounted on the circuit substrate in a region opposite to the second region with respect to the first region.

7. The optical module according to claim **6**, wherein the electronic component is mounted on the second mounting surface of the circuit substrate.

8. The optical module according to claim **1**, comprising a clip member for mechanically joining the optical coupling member to the optical fiber holding member.

9. The optical module according to claim **8**,

wherein the clip member is a member with thermal conductivity higher than that of the optical fiber holding member, and

wherein the clip member makes contact with at least a part of the second surface of the optical fiber holding member.

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